



SRT Status and Plans for Version-7

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AIRS Science Team Meeting

Greenbelt, MD

October 14, 2015

Background

The AIRS Science Team Version-6 retrieval algorithm is currently producing level-3 Climate Data Records (CDRs) from AIRS that have been proven useful to scientists in understanding climate processes. CDRs are gridded level-3 products which include all cases passing AIRS Climate QC.

SRT has made significant further improvements to AIRS Version-6. Research is continuing at SRT toward the development of AIRS Version-7. At the last Science Team Meeting, we described results using SRT AIRS Version-6.19. SRT Version-6.19 is now an official build at JPL called 6.2. SRT's latest version is AIRS Version-6.22. We have also adapted AIRS Version-6.22 to run with CrIS/ATMS. AIRS Version-6.22 and CrIS Version-6.22 both run now on JPL computers, but are not yet official builds.

The main reason for finalization of Version-7, and using it in the relatively near future for the future processing and reprocessing of old AIRS data, is to produce even better CDRs for use by climate scientists. For this reason all results shown in this talk use only AIRS Climate QC.

Major Improvements in Version-6.22 Over Version-6

Version-6.22 is built on Version-6 with some modifications in details.

The major changes are given below:

- The $O_3(p)$ retrieval step uses many more channels and also simultaneously solves for surface spectral emissivity in the vicinity of the O_3 absorption band near 1000 cm^{-1} . Version-6.22 retrievals of $O_3(p)$ have improved considerably compared to Version-6.
- The $q(p)$ retrieval step uses many more channels in Version-6.22 compared to Version-6 and also allows for changes from the $q(p)$ first guess which have more vertical structure than Version-6, especially in the boundary layer. Version-6.22 retrievals of $q(p)$ have improved considerably compared to Version-6.
- The $T(p)$ retrieval step now includes tropospheric sounding CO_2 channels, but only if the corrections made to obtain the cloud cleared brightness temperatures of those channels, Θ_i^{CC} , are less than 5K. We also loosened the $T(p)$ Data Assimilation (DA) QC thresholds to allow for more cases, while still keeping RMS errors of $T(p)$ with QC=0 to be on the order of 1K or less.

Comparison of AIRS Version-6, AIRS Version-6.22, and CrIS Version-6.22 Results

The following results are shown for the single day, December 4, 2013. EOS Aqua and NPP orbits overlap closely on this day. This is important for comparison purposes to minimize time-of-day sampling differences. This day also occurs after the major upgrade in ATMS calibration procedures.

The major improvements of Version-6.22 compared to Version-6 are with regard to water vapor profile and total O_3 . The next figure shows level-2 $q(p)$ results, using Climate QC thresholds, for all these experiments in terms of yields, RMS errors, and biases compared to ECMWF.

We next show, AIRS Version-6, AIRS Version-6.22, and CrIS/ATMS Version-6.22 level-3 gridded fields and compare them to measures of truth for total O_3 burden and total precipitable water (W_{tot}). AIRS and CrIS results using Version-6.22 are each significantly improved compared to Version-6 for both water vapor and ozone products.

December 4, 2013 Global Statistics using Climate QC

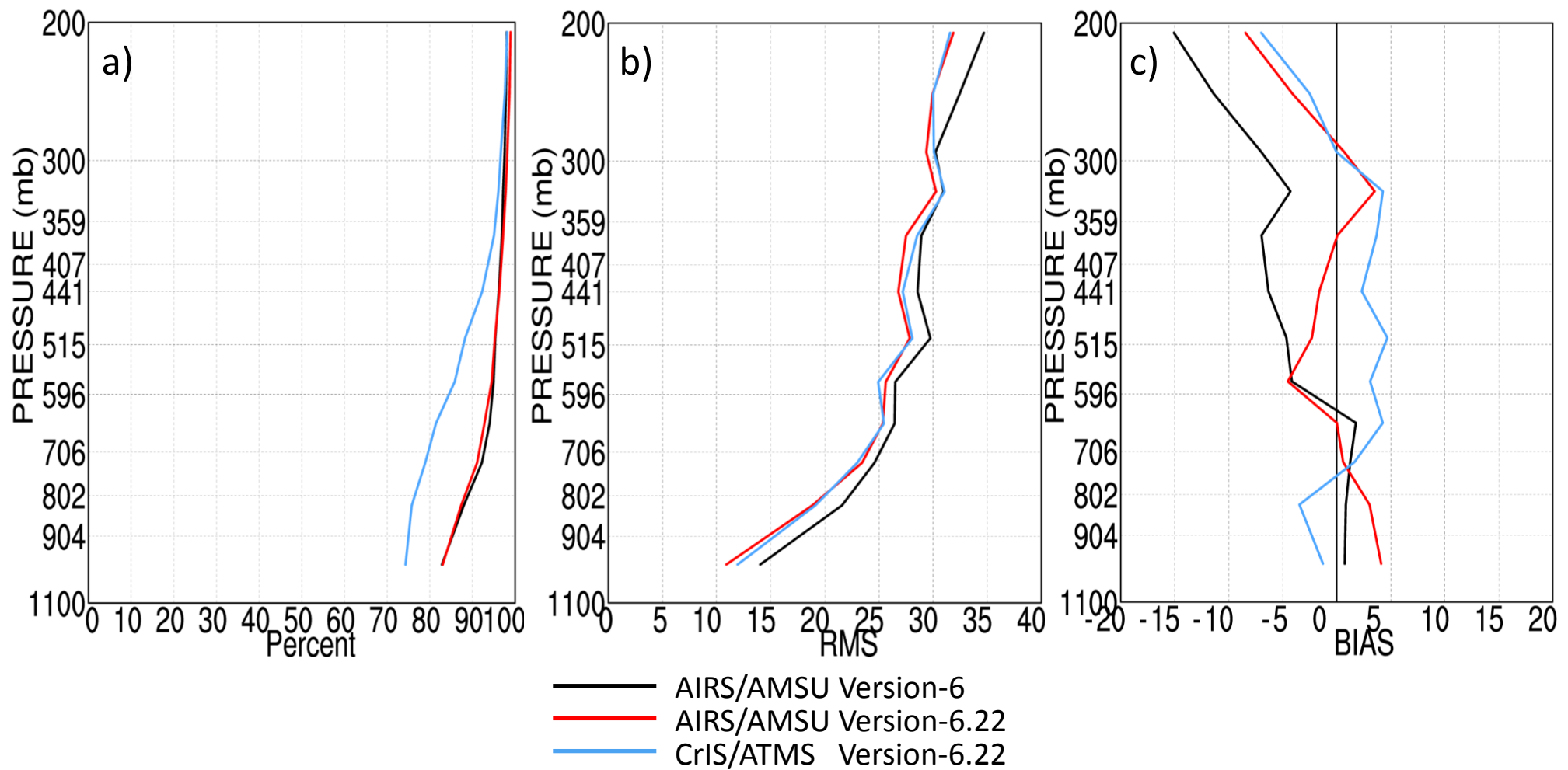
Percent of all Cases Accepted

1km Layer Precipitable Water

1km Layer Precipitable Water

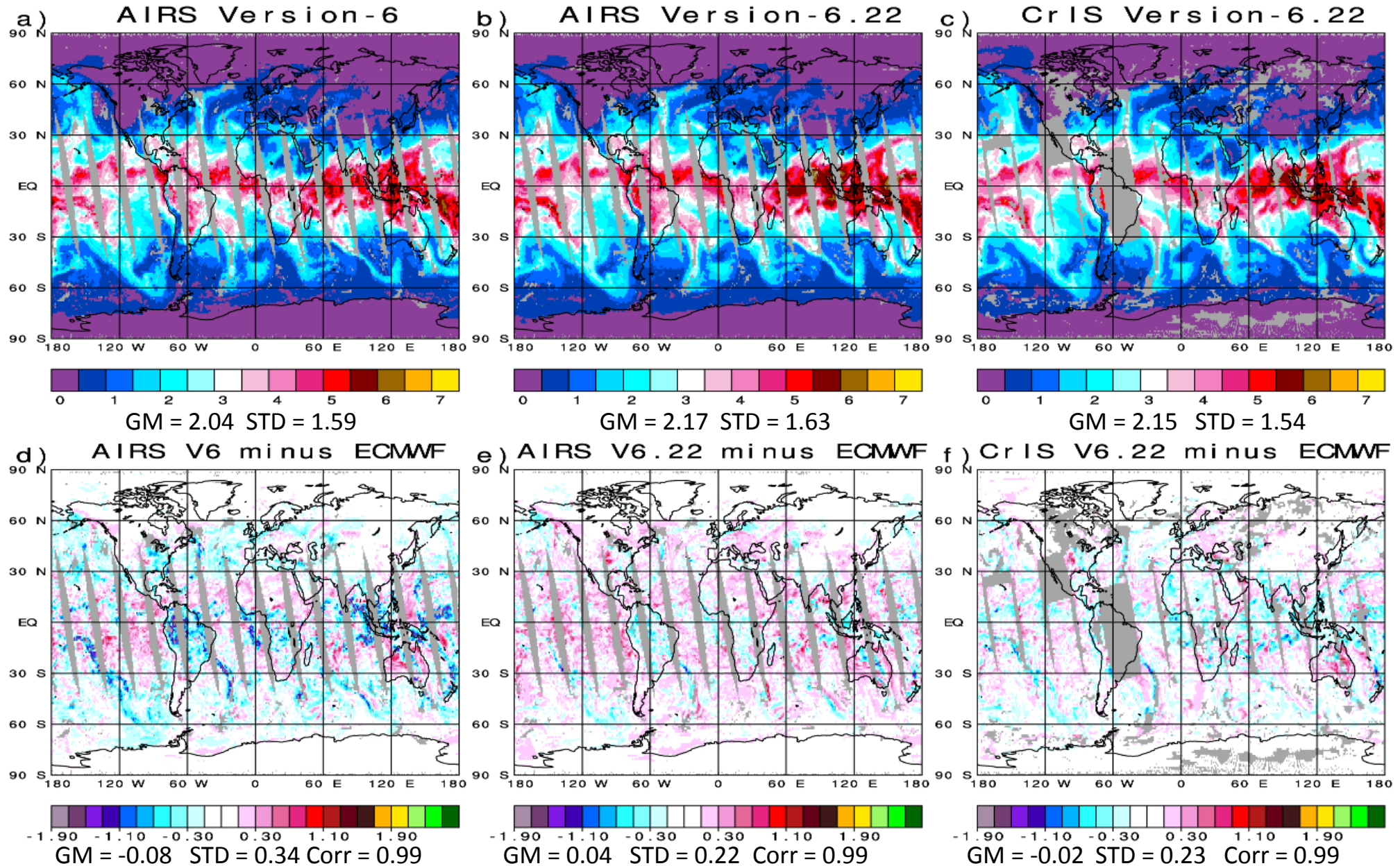
RMS % Differences From ECMWF

Bias % Differences From ECMWF



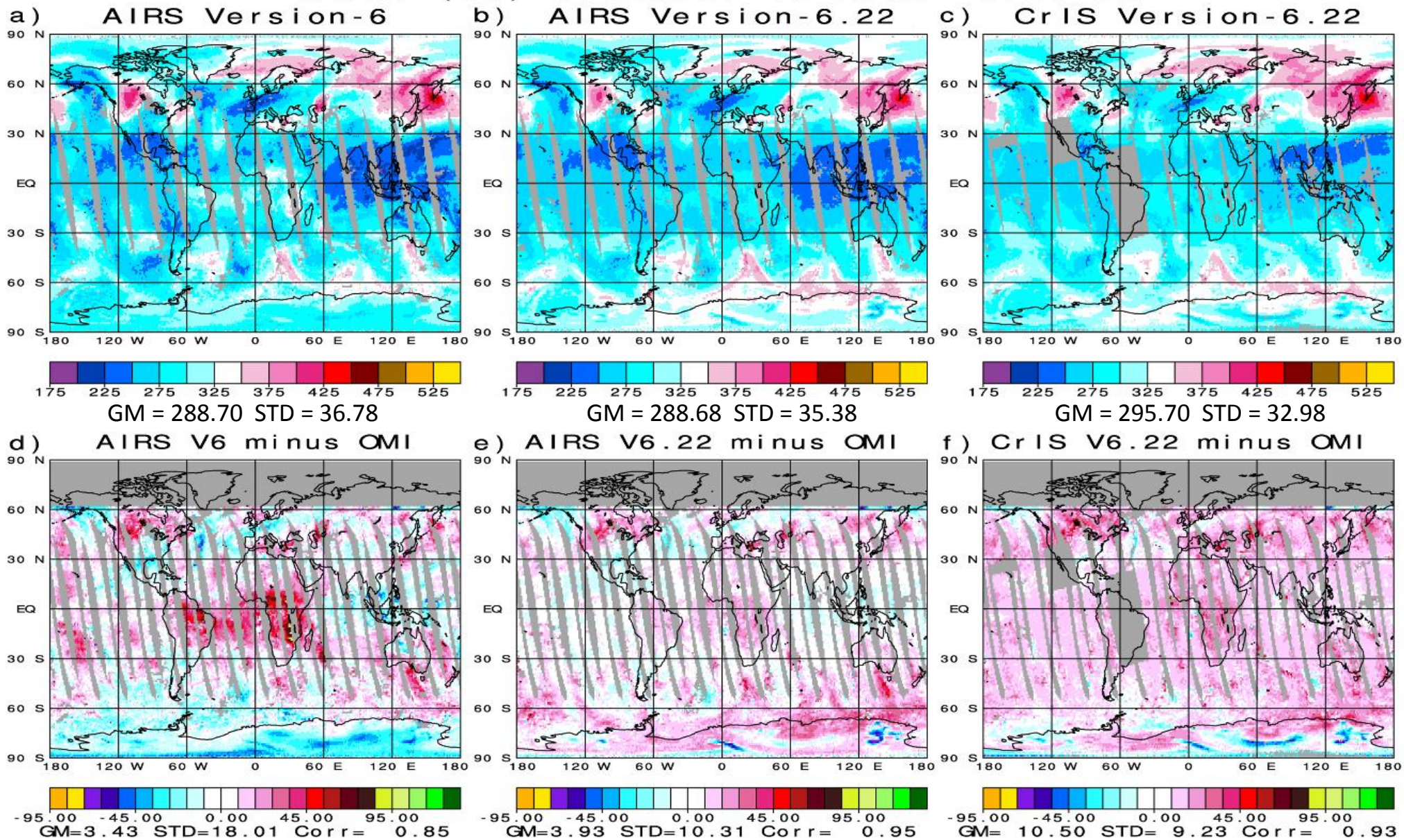
AIRS and CrIS Version-6.22 results are both superior to those of AIRS Version-6 with regard to both RMS errors and biases. Version-6 RMS errors are poorest at all levels of the atmosphere, and AIRS Version-6 is biased dry as compared to ECMWF in the upper troposphere.

December 4, 2013 Total Precipitable Water (cm) 1:30 PM



QC'd fields of Total Precipitable Water (W_{TOT}) for the ascending (1:30 PM) orbits of AIRS and CrIS, and their differences from the ECMWF 3-hour forecast for this time period, which we take as truth. AIRS V-6.22 W_{tot} is much more accurate than V-6, especially in areas of high cloud cover. CrIS V-6.22 W_{tot} results are comparable to those of AIRS V-6.22.

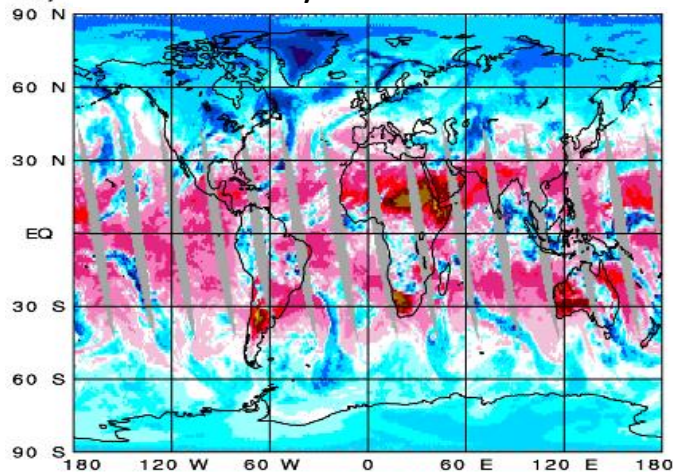
Ozone (DU) December 4, 2013 1:30 PM



AIRS Version-6, AIRS V-6.22, and CrIS V-6.22 QC'd fields of total O_3 for ascending orbits on December 4, 2013, and their differences from OMI. AIRS V-6.22 agrees much better with OMI than AIRS V-6 with regard to both STD and spatial correlation. CrIS V-6.22 statistics are comparable to AIRS V-6.22 but CrIS O_3 is biased high compared to OMI.

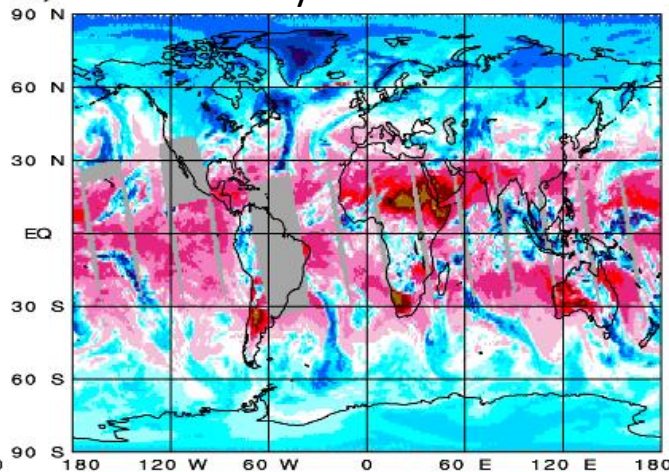
Outgoing Longwave Radiation (Watts/m²) December 4, 2013 1:30 PM

a) AIRS Cloudy OLR Version-6.22



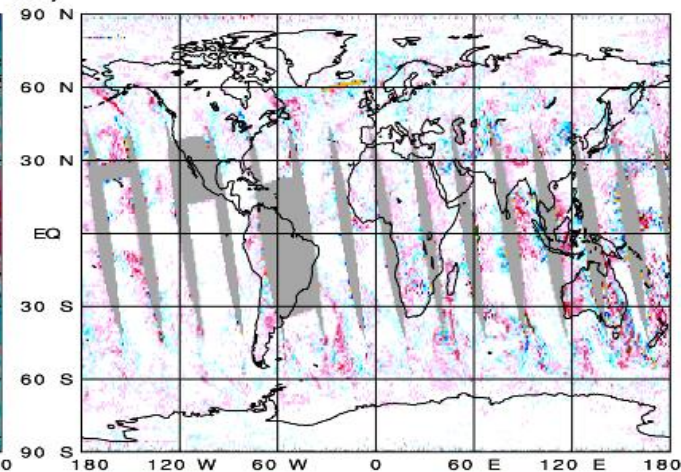
GM = 239.32 STD = 46.41

b) CrIS Cloudy OLR Version-6.22



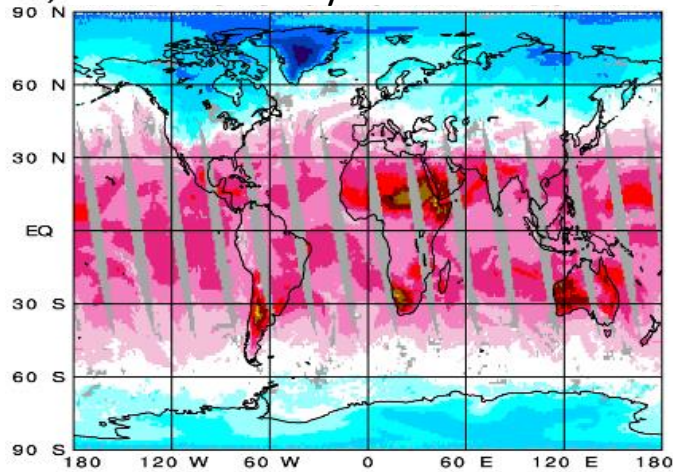
GM = 240.13 STD = 46.75

c) AIRS minus CrIS



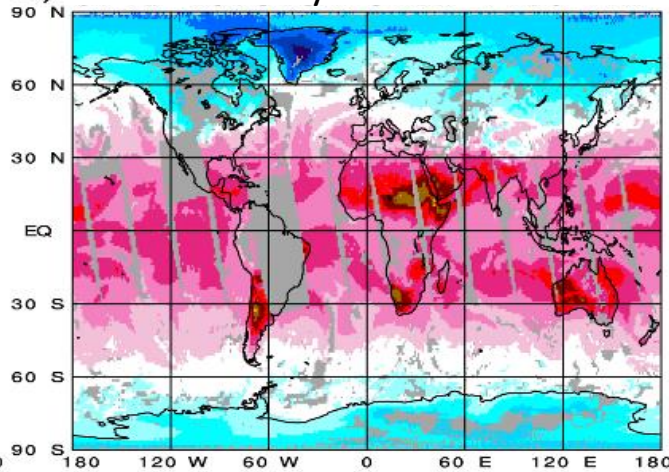
GM = 0.32 STD = 7.16 Corr = 0.99

d) AIRS Clear Sky OLR Version-6.22



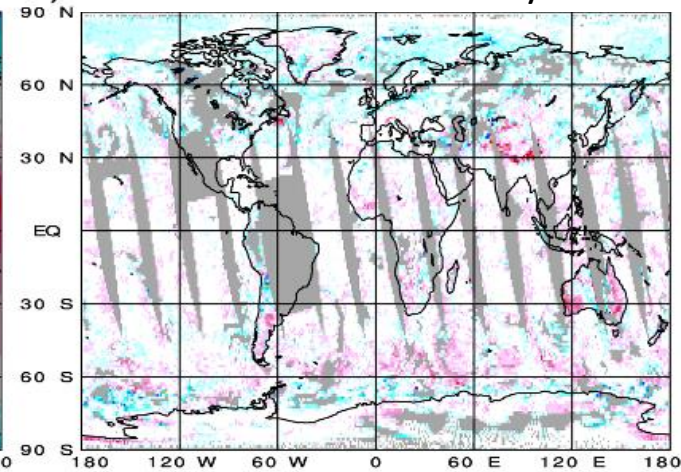
GM = 262.32 STD = 33.74

e) CrIS Clear Sky OLR Version-6.22



GM = 266.05 STD = 31.23

f) AIRS minus CrIS Clear Sky OLR



GM = -0.20 STD = 3.41 Corr = 1.00

AIRS and CrIS values of computed OLR and clear sky OLR for ascending orbits on December 4, 2013. Agreement of both fields is excellent with regard to global mean and spatial correlation. Some of the differences in AIRS and CrIS OLR are a result of EOS Aqua and NPP orbits not aligning as well east of 90 E.

Findings Using Version-6.22

We tested and evaluated Version-6.22 AIRS and Version-6.22 CrIS products on a single day, December 4, 2013, and compared the results to those derived using AIRS Version-6.

- AIRS and CrIS Version-6.22 $O_3(p)$ and $q(p)$ products are both significantly superior to those of AIRS Version-6
- All AIRS and CrIS products agree reasonably well with each other

Updates to the calibration of both CrIS and ATMS are still being finalized. JPL plans, in collaboration with the Goddard DISC, to reprocess all AIRS data using a still to be finalized Version-7 retrieval algorithm, and to reprocess all recalibrated CrIS/ATMS data using Version-7 as well.

We hope to be able to begin CrIS/ATMS processing at the DISC in one year. It would behoove the AIRS Science Team to begin reprocessing of AIRS data using an improved Version-7 algorithm no later than the DISC begins CrIS processing, so HQ and users do not get the misleading impression that CrIS products are better than those of AIRS.

Proposed Approach for Finalization of Version-7

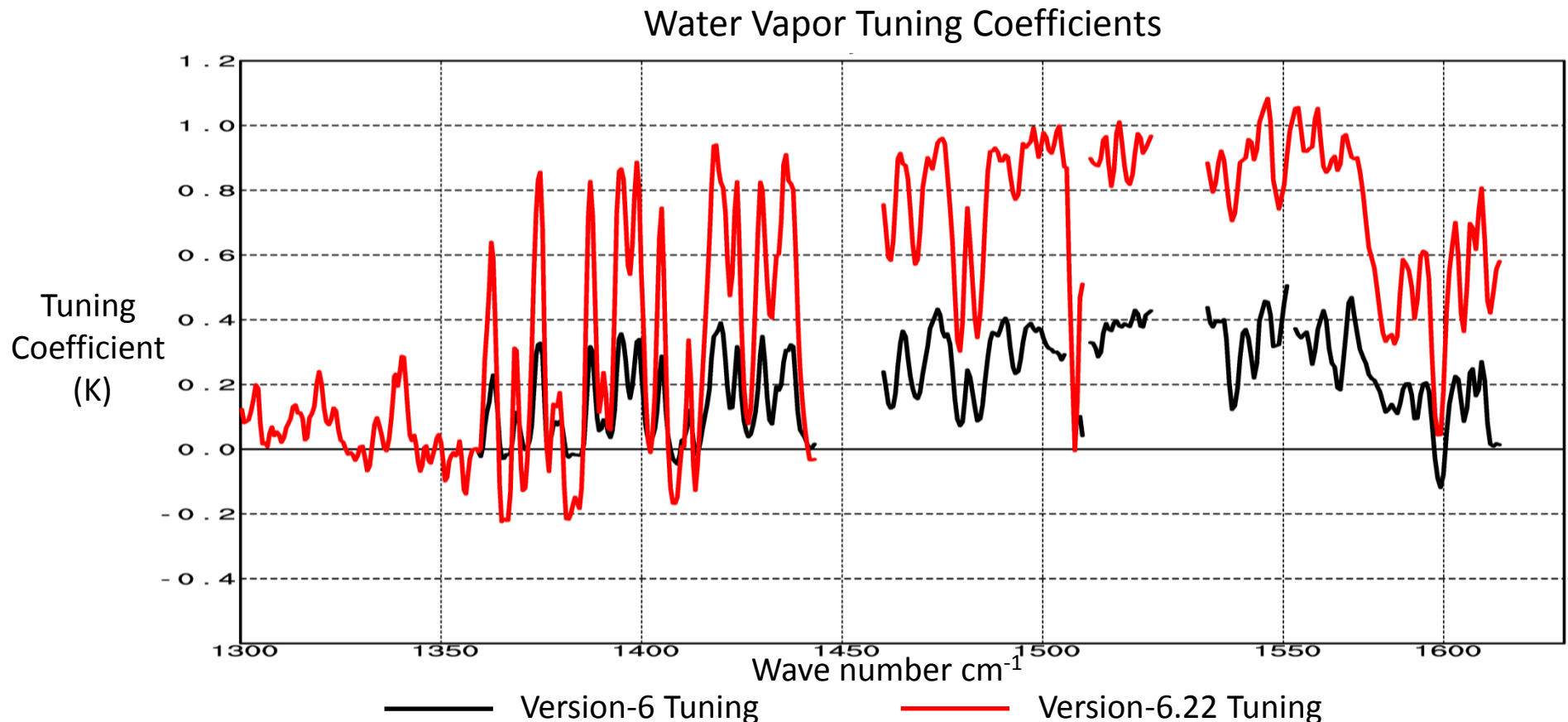
Ideally the AIRS Science Team should test and evaluate proposed Version-7 by the next AIRS Science Team Meeting, roughly six months from now. This means proposed AIRS Version-7 should be finalized three months from now and a potentially final build be made then at JPL. We welcome suggestions from others for further improvements, but we must have them and test them in the next three months.

SRT Version-6.22 is already improved compared to SRT Version-6.19, which is JPL Version-6.2. The next few slides describe changes in SRT Version-6.22 compared to Version-6.19. We made further improvements in Version-6.22 in details of the methodology used in both the retrieval of water vapor profile $q(p)$ and the temperature profile $T(p)$. We anticipate V-7 will contain further relatively minor improvements beyond those in V-6.22.

Modifications in Version-6.22 from Version-6.19

Water vapor profile retrieval step

We computed new tuning coefficients and use them between 1360 cm^{-1} and 1630 cm^{-1} . This reduced the dry upper tropospheric water vapor bias found in both Version-6 and Version-6.19. This also allowed us to add 22 more water vapor channels to the retrieval step, including the strongest lines. The AIRS Version-6 tuning coefficients were derived at NOAA. We find that the new coefficients perform better.



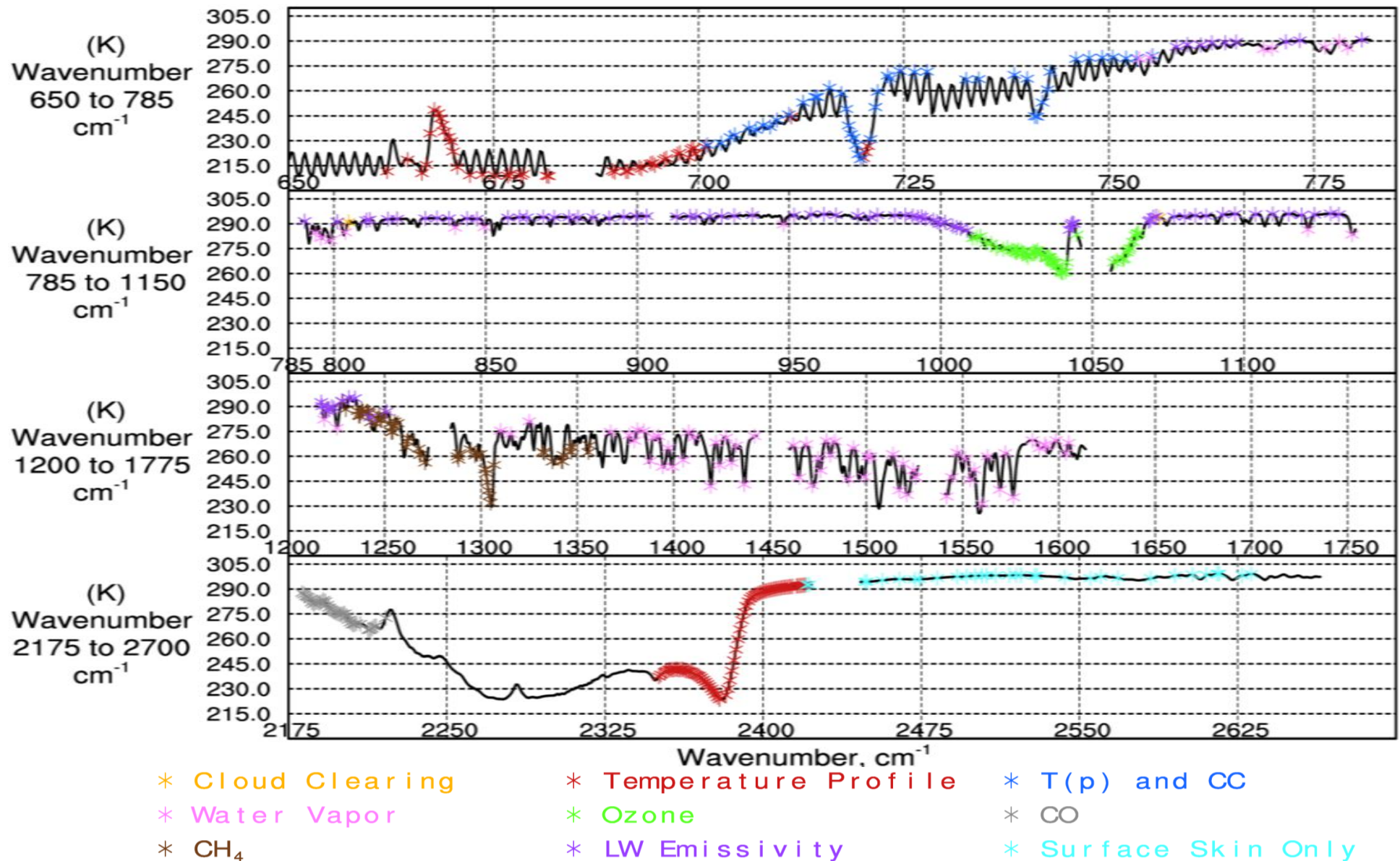
Modifications in Version-6.22 from Version-6.19

Temperature profile retrieval step

Version-5 and Version-6 used tropospheric sounding $15\ \mu m$ channels only for the purpose of deriving cloud clearing coefficients. They were not included in the $T(p)$ retrieval step because errors in cloud clearing coefficients result in larger errors in Θ_i^{CC} for $15\ \mu m$ channels compared to those for $4.3\ \mu m$ channels. Large initial cloud clearing coefficient errors can occur if the initial guess is poor, and including $15\ \mu m$ channels in the $T(p)$ retrieval step can then result in poor retrievals. This does not often occur with a Neural-Net guess. Therefore, in Version-6.22 we added $15\ \mu m$ temperature sounding channels between $714\ \text{cm}^{-1}$ and $742\ \text{cm}^{-1}$ to the $T(p)$ retrieval step, with the case-by-case provision that the cloud clearing correction to a channel brightness temperature not exceed 5K. We also applied the 5K cloud clearing correction check to all other channels in both the temperature and water vapor profile retrieval steps.

Sample Cloud Free Brightness Temperature Spectrum

AIRS Version-6.22 Channels



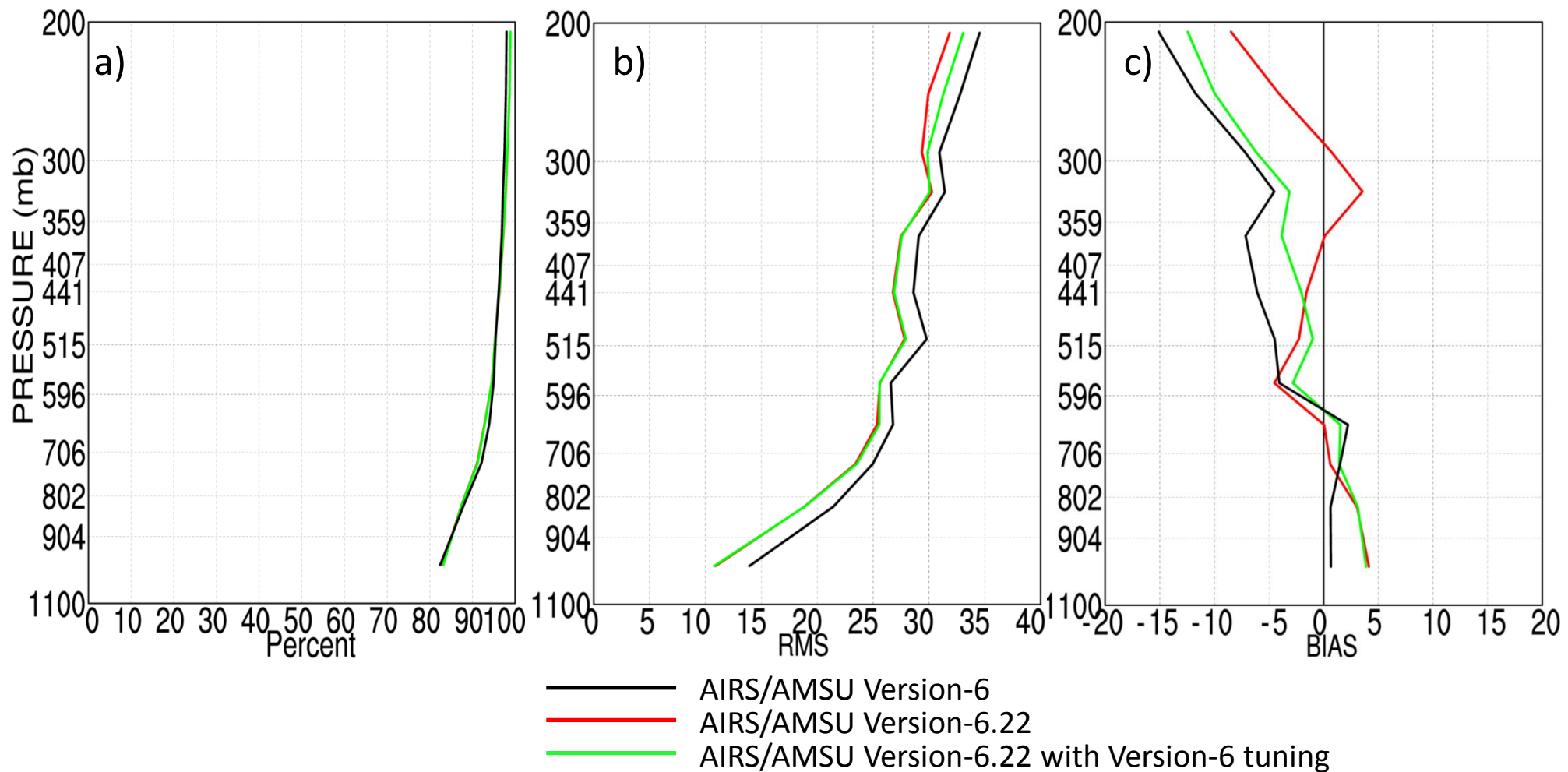
Sample AIRS brightness temperature computed for cloud free scenes. The AIRS channels we use in different steps in the retrieval process are indicated in the figures by different colored stars. Dark blue shows 15 μm channels now used in the $T(p)$ retrieval.

December 4, 2013 Global Statistics Climate QC

Percent of all Cases Accepted

1km Layer Precipitable Water
RMS % Differences From ECMWF

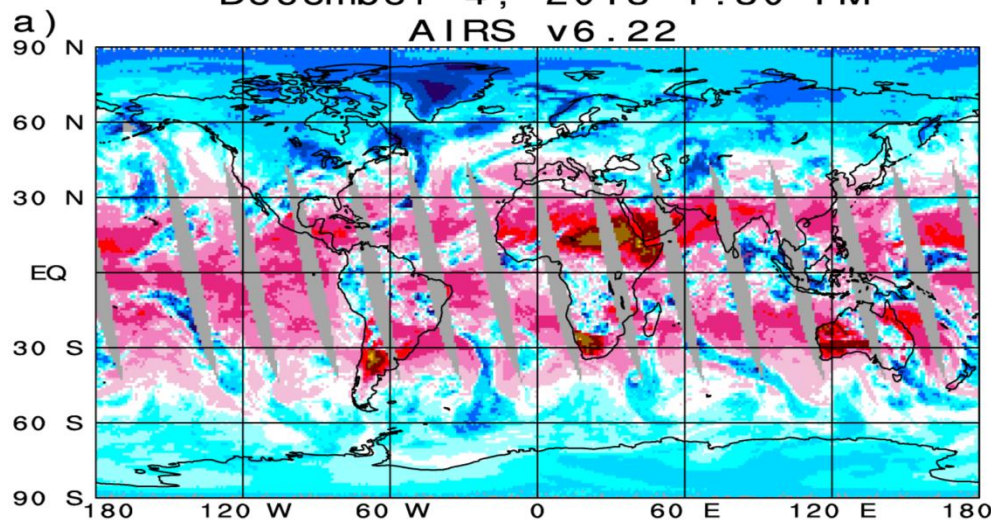
1km Layer Precipitable Water
Bias % Differences From ECMWF



The red and black curves are as shown before. Other modifications in Version-6.22 improve the water vapor profile at all levels in the atmosphere compared to Version-6, but use of the new tuning in addition to other changes significantly decreases the dry bias in upper tropospheric water vapor.

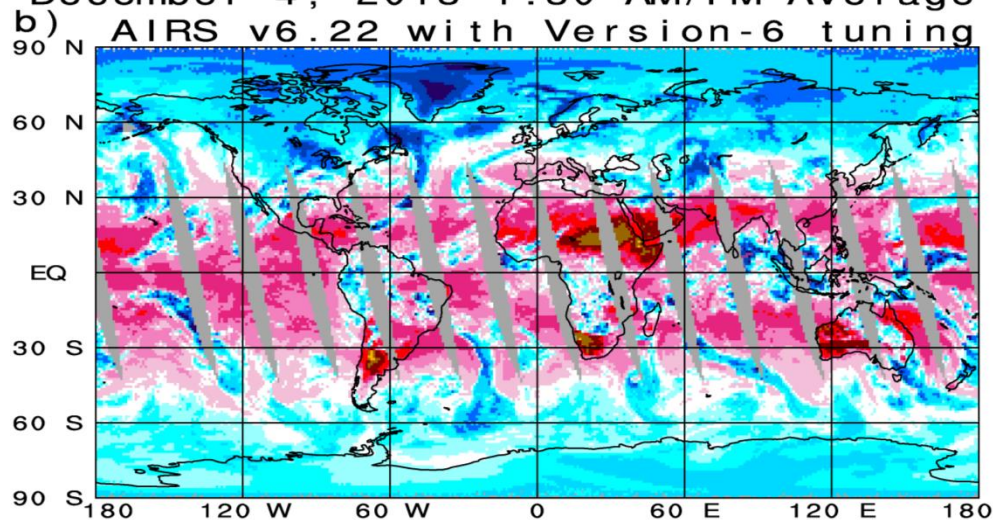
Outgoing Longwave Radiation (Watts/m²)

December 4, 2013 1:30 PM
AIRS v6.22



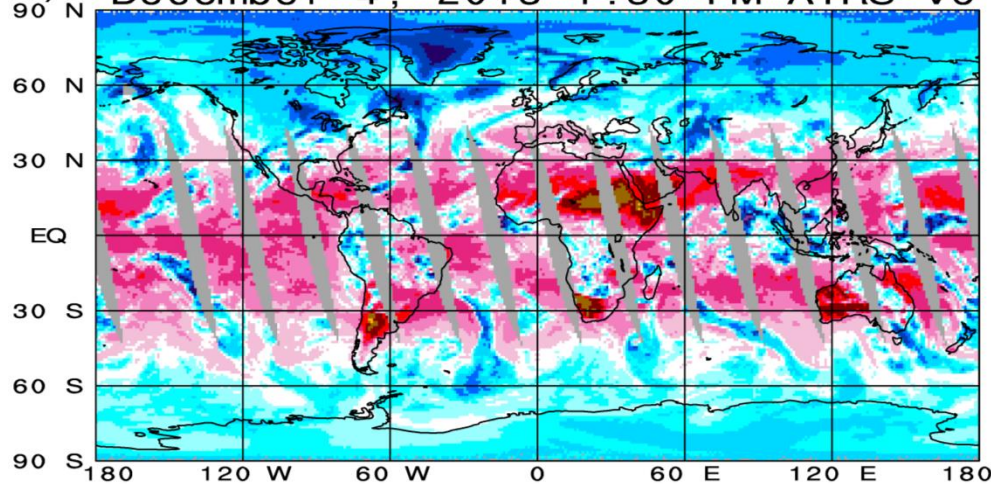
Mean = 239.61 STD = 46.24

December 4, 2013 1:30 AM/PM Average
AIRS v6.22 with Version-6 tuning



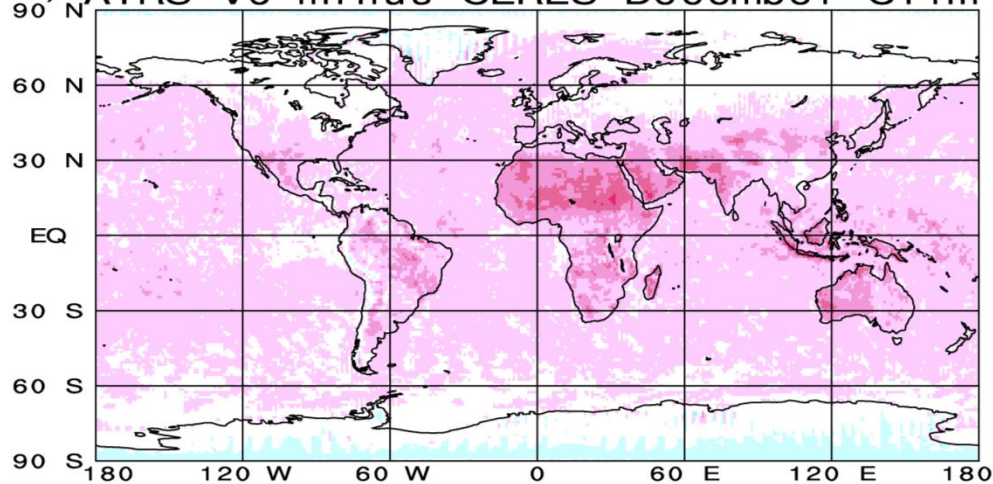
Mean = 239.86 STD = 46.30

c) December 4, 2013 1:30 PM AIRS V6



Mean = 239.91 STD = 45.86

d) AIRS V6 minus CERES December Clim



Mean = 3.28 STD = 2.23 Corr = 1.00

The decrease in upper tropospheric water dry bias using new tuning lowers Global Mean OLR by 0.25 W/m². This would further decrease the small bias of AIRS V-6 OLR compared to CERES by about 10%.

Additional Requirements for Version-7

As presented at the April 2015 Science Team Meeting, at least two additional items need further improvement before possible reprocessing of the AIRS data.

- Version-6.19 total O_3 has spurious high values in the presence of Saharan dust over the ocean.
- Version-6 retrieved upper stratospheric temperatures are very poor in polar winter. This could also degrade total O_3 .

Neither of these has thus far been addressed in Version-6.22.

We have made progress since Version-6.22 with regard to improvements in O_3 profile QC that identifies some ocean cases as having spuriously high O_3 values resulting from Saharan dust. More work needs to be done here.

We have confirmed that the source of poor retrieved upper stratospheric temperature in polar winter is poor performance of the AIRS Neural-Net $T(p)$ coefficient in polar winter. The analogous poor performance does not occur using CrIS Neural-Net coefficients. We have received sample new Neural-Net coefficients from Bill Blackwell.

Proposed Short Term Schedule

- JPL Version-6.3 build \approx November 13

We plan to conduct further research beyond SRT Version-6.22 in the next month in preparation for a next build, JPL Version-6.3. The main goal of our short term research is to further improve the total O_3 product as compared to OMI, and in particular to flag most oceanic cases affected by Saharan Dust as bad retrievals. We will look at improving other aspects of the retrieval algorithm as well. We welcome suggestions and appropriate code by others.

- Potential final build \approx January 8

This schedule allows for 3 months testing and evaluation of results by the next Science Team Meeting. This build must include use and testing of improved AIRS/AMSU and "AIRS Only" Neural-Net coefficients, or else we are not ready to go. We will be happy to include and test any suggestions by others in this potentially final build. Proposed modifications to this build by others should be in place by January 8th for testing and evaluation.

